Claims

1. Method for controlling the lean operation of an internal combustion engine, especially an internal combustion engine of a motor vehicle, provided with a nitrogen oxide storage catalyst,

in which the nitrogen oxides produced by the internal combustion engine in a first operating phase (lean operation) as the storage phase are stored for a specific storage time in the nitrogen oxide storage catalyst, and

in which, after the storage time expires, by a control device as the engine control at a specific switching instant for a specific discharge time switching to a second operating phase (rich operation) takes place as the discharge phase in which the nitrogen oxides which have been stored during the storage time are discharged from the nitrogen oxide storage catalyst,

the nitrogen oxide mass flow upstream of the nitrogen oxide storage catalyst and/or the nitrogen oxide mass flow downstream of the nitrogen oxide storage catalyst each being integrated over the same time interval,

characterized in that

in a first process step, to establish the instant of switching from the storage phase to the discharge phase, a switching operating point is determined at least from the integral value of the nitrogen oxide mass flow upstream and/or downstream of the storage catalyst, and

that the respective switching operating point is compared in a second process step to a definable operating field which is optimized especially with respect to the fuel savings potential as a function of the load acceptance of the internal combustion engine, which is formed by a plurality of individual operating points for one new and one aged storage catalyst such that

for a switching operating point which is located within the operating field the engine control enables lean operation and thus switching between the storage phase and the discharge phase of the nitrogen oxide storage catalyst, while the engine control conversely dictates lambda operation of the internal combustion engine at which lambda is equal to 1 for a switching operating point which departs from the definable operating field.

2. The process as claimed in claim 1, wherein

the operating field is spanned depending on the load essentially by a savings potential boundary curve for a new nitrogen oxide storage catalyst and by a savings potential boundary curve for an aged storage catalyst which represents a boundary ageing state.

3. The process as claimed in claim 1 or 2, wherein

to establish the switching instant from the storage phase to the discharge phase, a relative nitrogen oxide slip as the difference between the nitrogen oxide mass flow which has flowed into the nitrogen oxide storage catalyst and the nitrogen oxide mass flow which has flowed out of the nitrogen oxide storage catalyst is determined relative to the storage time such,

that the quotient of the integral values of the nitrogen oxide mass flow upstream and downstream of the nitrogen oxide storage catalyst moreover is brought into a relative relationship with a definable degree of nitrogen oxide conversion which has been derived from the exhaust boundary value, so that when these given switching conditions are present in the case of a switching operating point which is within the operating field, switching from the storage phase (lean operation) to the discharge phase (rich operation) is carried out at the switching instant which has been optimized with respect to fuel consumption and the storage potential.

4. The process as claimed in claim 3, wherein

the relative slip is the quotient of the integral over the nitrogen oxide mass flow downstream of the nitrogen oxide catalyst and of the integral over the nitrogen oxide mass flow upstream of the nitrogen oxide catalyst and

wherein this quotient for determining the switching condition is set equal to the definable switching threshold value K which originates from the definable degree of nitrogen oxide conversion so that when this switching condition is met, switching to the discharge phase takes place from the storage phase at the end of the storage time which was thus determined.

5. The process as claimed in claim 4, wherein

the switching threshold valve K satisfies the following equation:

K = 1 - defined rate of nitrogen oxide conversion

with a given rate of nitrogen oxide conversion of less than 1, preferably with a given rate of nitrogen oxide conversion of at least 0.80, at most preferably of 0.95.

6. The process as claimed in one of claims 1 to 5, wherein

to determine the degree of ageing of the storage catalyst from the integral value of the nitrogen oxide mass flow upstream and/or downstream of the storage catalyst and/or the switching instant when the switching condition is met, moreover the switching operating point is determined as a function of the instantaneous operating temperature at the switching instant, and

wherein the respective switching operating point is compared in a second stage for determining the degree of ageing of the storage catalyst to a definable storage catalyst capacity field which is optimized especially with respect to fuel consumption, which runs over a temperature window, and which is formed by a plurality of individual operating points for a new and an aged storage catalyst such

that the switching operating point which lies within the storage catalyst capacity field does not constitute a failure to reach the minimum nitrogen oxide storage capacity, but represents the change relative to the prior operating point as a measure of storage catalyst ageing, and

wherein a switching operating point which departs from the storage catalyst capacity field indicates a failure to reach the minimum nitrogen oxide storage capacity.

7. The process as claimed in claim 6, wherein

the storage catalyst capacity field relative to the temperature window on the one hand is limited by the boundary line for a new storage catalyst and on the other hand by the boundary line for an aged storage catalyst which constitutes a boundary ageing state.

8. The process as claimed in claim 6 or 7, wherein

the temperature window comprises temperature values between approximately 200°C and approximately 450°C.

9. The process as claimed in one of claims 6 to 8, wherein

an error signal in the engine control device is set in the event of a failure to reach the minimum nitrogen oxide storage capacity.

10. The process as claimed in one of claims 1 to 9, wherein

the nitrogen oxide mass flow is modeled upstream of the nitrogen oxide storage catalyst.

11. The process as claimed in one of claims 1 to 10, wherein

the nitrogen oxide mass flow is measured downstream of the nitrogen oxide storage catalyst by means of an nitrogen oxide sensor.